Types and Classification of Nerve Injury: A Review

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ABSTRACT

Nerve injuries are the most common conditions with varying symptoms, depending on the severity, intensity and nerves involved. Though much information is available on the mechanisms of injury and regeneration, reliable treatments that ensure full functional recovery are limited. The type of nerve injury alters the treatment and prognosis. This review article aims to summarize the various types of nerve injuries and their classification.

Keywords: Axonotmesis, neurotmesis, neurapraxia, Wallerian degeneration

Nerve injuries are the most common conditions with varying symptoms depending on the severity, intensity and nerves involved. Recovery after any nerve injury is variable. Though much information exists on the mechanisms of injury and regeneration, reliable treatments that ensure full functional recovery are limited. The type of nerve injury alters the treatment and prognosis. This review article aims to summarize the various types of nerve injuries and classification of nerve injuries, which is useful in understanding their pathological basis, and to evaluate the prognosis for recovery.

Understanding the basic nerve anatomy is important for the classification and also essential to evaluate the clinical prognostic value. In the central nervous system (CNS) and peripheral nervous system (PNS), there are three connective tissue layers:

- *Endoneurium:* Individual nerve fibers (single axons) are covered with varying amounts of myelin and then covered by endoneurium.
- *Perineurium:* These individually wrapped nerve fibers (endoneurium) are then grouped into bundles of fibers called fascicles, which are covered by perineurium.
- *Epineurium:* Finally, groups of fascicles are bundled together to form the peripheral nerve (such as the median nerve), which is covered by epineurium.

CLASSIFICATION

Classification by Type of Nerve Injury

There are three types of nerve injuries:

Nerve section

Nerve section can be partial or complete, sharp or blunt. They are often caused by sharp wounds by glass, firearms or knives.

Nerve strecthing

Stretching can occur in association with displaced fractures. During traction, the perineurium is elongated, the axons and epineurium stretch and tear.

Nerve compression

Compression can either be extrinsic or intrinsic. Extrinsic is more common in median nerve injury in the carpal tunnel and ulnar nerve at the elbow. Intrinsic compression is usually caused by the nerve tumor.

There are two mechanisms of peripheral nerve injury resulting from compression:

- *Indirect mechanism:* Acute or repeated prolonged compression may cause vascular stasis with increased vascular permeability and formation of endoneurial edema.
- *Direct mechanism:* A direct mechanical damage to the myelin sheath or the axon itself, thus restricting nerve conduction.

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Anatomical Nerve Injury

There are two main types of nerve injuries based on the part involved and classified based on correlation with the electromyography (EMG) finding:

- Seddon's classification
- Sunderland's classification.

Seddon's classification

Seddon provided a basis for assessment, prognosis and management of nerve injury. He classified nerve injuries into three categories - neurapraxia, axonotmesis and neurotmesis.

Neurapraxia

It is the least severe nerve injury, caused by transient compression or stretch. Conduction block results in loss of nerve function. Paralysis of muscles innervated by the nerve is complete. This type of injury will recover completely provided the cause, for example, ongoing compression, is removed. Recovery will take hours to months (average 6-8 weeks).

Axonotmesis

This is an anatomical interruption of the axon with no or only partial interruption of the connective tissue (endoneurium, perineurium and epineurium). This type of nerve injury requires regeneration of about 1.5-3 mm/day of the axon to the target muscle which is inhibited by scar formation. Wallerian degeneration occurs due to loss of axoplasmic flow. Patients with axonotmesis will require surgical treatment depending on the number of axons disrupted and the extent of scar formation at the site of nerve injury. Axons grow in adults at about 1 inch per month, and the recovery may take weeks to months. In infants, the axon may regenerate more rapidly, and the distance to be covered is much less. When a muscle loses its innervation, the nerve receptors will disappear over a period of 1-2 years. This may require neurosurgical intervention because a repair regenerated too late will not have receptors in the muscles for the regeneration of nerves.

Neurotmesis

Here, the nerve is completely disrupted or badly disorganized. This is the most severe form of nerve injury. Along with axons, all the connective tissue layers of the nerve are disrupted. There is axon degeneration distal to the injury. Neurotmesis may be caused by laceration or high energy traction injuries. Ischemia or injection of noxious drugs can also cause nerve injury. Recovery can only occur after appropriate surgical repair of the nerve and relies on axonal regeneration. Mixing and disruption of fibers at the site of the repair result in failure of correct distal connections. So, the recovery is either imperfect or incomplete.

Limitations of Seddon's classification

All grades of intraneural damage are not distinguished with Seddon's classification. Lesions classified as axonotmesis have been observed to have variable recovery. This could occur because variable degrees of damage to the connective tissue layers of the nerve, including the endoneurium and perineurium and disruption of axons are possible without loss of continuity of the nerve trunk.

Sunderland's classification

Sunderland, in 1951, described 5 degrees of nerve injury based on the disruption of the nerve and their continuity with the connective tissue. Mackinnon and Dellon added a 6th degree injury to Sunderland's classification where there was variable degrees of nerve injury.

- 1st degree - conduction block (neurapraxia).
- 2nd degree - axonal injury (axonotmesis).
- 3rd degree - axonal injury with endoneurium injury.
- 4th degree - axonal injury with endoneurium injury and perineurium injury.
- 5th degree - axonal injury with endoneurium injury, perineurium injury and neurapraxia.
- 6th degree - combination of previous injuries.

Table 1 summarizes the correlation between Sunderland and Seddon classifications and intact connective tissue.

DISCUSSION

If there is a trauma and signs of a nerve injury then surgery will be necessary to look at the nerve and if there, whether it has been partly or completely disrupted. If there is no wound, then it is likely that a "wait and watch" policy will be adopted. Under these circumstances, further investigations may be carried out to try and assess the damage to the nerve. There are various investigation methods to diagnose the degree of nerve injury; this is done using neurophysiology testing where the nerves are stimulated with an electric current and the speed at which the nerve conducts is measured (electromyography). Neurophysiology tests can distinguish between injuries where axons have not degenerated (neurapraxia) and those where axons have degenerated distally (axonotmesis and

Table 1. Correlation Between Sunderland and Seddon Classifications and Intact Connective Tissue

Sunderland's	Seddon's	Axon	Endoneurium	Perineurium	Epineurium	Fibrillation potential on EMG	Clinical sign	Recovery
1st degree	Neurapraxia	+	+	+	+	Absent	Paresthesia, partial or total palsy	Full (1 day to 3 months)
2nd degree	Axonotmesis	–	+	+	+	Present	Paresthesia, partial or total palsy	Generally full (1-6 months)
3rd degree	Axonotmesis	–	–	+	+	Present	Paresthesia, dysesthesia, partial or total palsy	Partial (12-24 months)
4th degree	Axonotmesis	–	–	–	+	Present	Hypoesthesia, dysesthesia, total palsy	None without repair
5th degree	Neurotmesis	–	–	–	–	Present	Anesthesia, total palsy	None without repair
6th degree	Combination of prevoius injury	–	–	–	–	Present	Paresthesia, partial or total palsy	None without repair

'+' = Intact nerve; '–' = Injured nerve (not intact).

neurotmesis). If axonotmesis has affected all the fibers in a nerve, then the findings will be indistinguishable neurotmesis. However, in mixed lesion, with some fibers intact, detection of these will imply that there is no disruption of the nerve trunk. In addition, very fine needles may be inserted into an affected muscle and recordings made of the activity in that muscle. Normal nerves can be visualized on magnetic resonance imaging (MRI), although their signal characteristics are not distinct from other tissues. A technique called magnetic resonance neurography, which enhances neural tissue on images, was reported by Filler. Modern ultrasound scanners have improved to the extent that resolution is now greater than MRI. Ultrasound is being used increasingly to examine nerves damaged by closed trauma. These will help to grade the level of injury and can help in treatment planning and giving information on the potential outcome of the injury.

CONCLUSION

The result of a nerve injury depends on many variables, as detailed in this article. The important thing to remember is that nerves take many months to years to repair and recover. The final result may not be known for 2 years or more. The purpose of this article is to outline the main types, classification and correlating the nerve injuries to evaluate their clinical value and to improve the prognosis of nerve recovery.

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